SYSTEM AND METHOD FOR REPLACING DEGENERATED SPINAL DISKS

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CROSS-REFERENCED CASES

[0001] The following U.S. Patent Applications are cross-referenced and incorporated herein by reference: ARTIFICIAL VERTEBRAL DISK REPLACEMENT IMPLANT WITH TRANSLATING PIVOT POINT AND METHOD, U.S. Provisional Patent Application No. 60/422,039, Inventor: James F. Zucherman et al., filed on October 29, 2002; ARTIFICIAL VERTEBRAL DISK REPLACEMENT IMPLANT WITH TRANSLATING PIVOT POINT AND METHOD, U.S. Patent Application No.: 10/684,669, Inventor: James F. Zucherman et al., filed on October 14, 2003; ARTIFICIAL VERTEBRAL DISK REPLACEMENT IMPLANT WITH CROSSBAR SPACER AND METHOD, U.S. Provisional Patent Application No.: 60/422,021, Inventor: Steve Mitchell, filed on October 29, 2002 ; ARTIFICIAL VERTEBRAL DISK REPLACEMENT IMPLANT WITH CROSSBAR SPACER AND METHOD, U.S. Patent Application No.: 10/684,668, Inventor: Steve Mitchell, filed on October 14, 2003 ; ARTIFICIAL VERTEBRAL DISK REPLACEMENT IMPLANT WITH A SPACER AND METHOD, U.S. Provisional Patent Application No.: 60/422,022, Inventor: Steve Mitchell, filed on October 29, 2002; ARTIFICIAL

VERTEBRAL DISK REPLACEMENT IMPLANT WITH A SPACER AND METHOD, U.S. Patent Application No.: 10/685,011, Inventor: Steve Mitchell, filed on October 14, 2003.

TECHNICAL FIELD

[0002] The present invention relates to spinal disks and spinal disk replacement devices.

BACKGROUND

[0003] A common procedure for handling pain associated with degenerative spinal disk disease is the use of devices for fusing together two or more adjacent vertebral bodies. The procedure is known by a number of terms, one of which is vertebral interbody fusion. Interbody fusion can be accomplished through the use of a number of devices and methods known in the art. These include screw arrangements, solid bone implant methodologies, and fusion devices which include a cage or other mechanism which is packed with bone and/or bone growth inducing substances. All of the above are implanted between adjacent vertebral bodies in order to fuse the vertebral bodies together, alleviating associated pain.

[0004] There are a number of drawbacks to undergoing interbody fusion. One drawback is that interbody fusion at one or more levels of the spine may cause decreased motion of the spine. Another drawback is that having interbody fusion at one or more levels of the spine may cause more stress to be transferred to adjacent levels. Transferred stress may cause new problems to develop at other levels of the spine, which may lead to additional back surgery.

[0005] Alternatives to interbody fusion surgery have been proposed including the use of artificial spinal disks. Such artificial spinal disks act like cushions or "shock absorbers" between vertebrae and may contribute to the flexibility and motion of the spinal column. Thus a purpose and advantage of such artificial spinal disks is to replace a degenerated spinal disk, while preserving the range of motion of the spine. Replacement of a spinal disk with an artificial disk may treat underlying back pain, while protecting patients from developing problems at an adjacent level of the spine.

[0006] A number of different artificial disks have been proposed. For example, one such proposal includes an artificial disk primarily comprising two metal metallic plates between which is a core that allows for motion. Another proposal includes two spinal disk halves connected at a pivot point. Other artificial disks have been proposed in the art.

BRIEF DESCRIPTION OF THE FIGURES

[0007] Further details of embodiments of the present invention are explained with the help of the attached drawings in which:

[0008] FIG. 1A is a cross-sectional side-view along a sagittal plane of an artificial spinal disk positioned between adjacent vertebrae in accordance with one embodiment of the present invention;

[0009] FIG. 1B is an enlarged side view of an anterior end of the artificial spinal disk shown in FIG. 1A;

[0010] FIG. 1C is an enlarged side view of a posterior end of the artificial spinal disk shown in FIG. 1A;

[0011] **FIG. 1D** is a side view of the embodiment of the invention in **Fig. 1A** with internal structure shown in the dotted lines.

[0012] **FIG. 1E** is a side view of the embodiment of the invention in **Fig. 1A**.

[0013] **FIG. 2A** shows the artificial spinal disk of **FIG. 1A** during a forward bending motion of a spine;

[0014] **FIG. 2B** is an enlarged side view of an anterior end of the artificial spinal disk shown in **FIG. 2A**;

[0015] **FIG. 2C** is an enlarged side view of a posterior end of the artificial spinal disk shown in **FIG. 1A**;

[0016] **FIG. 3A** is a cross-sectional side view along a sagittal plane of an anterior end of an alternative embodiment of an artificial spinal disk of the present invention showing a latch or engagement mechanism that connects a lower housing and an upper housing;

[0017] **FIG. 3B** is a cross sectional side view of an urged-together anterior end of the artificial spinal disk of the alternative embodiment shown in **FIG. 3A**;

[0018] **FIG. 4** is a cross-sectional top plan view along a transverse plane of an artificial spinal disk in accordance with the embodiment **FIG. 1A** of the present invention;

[0019] **FIG. 5A** is a side view of a spacer in accordance with one embodiment of the present invention;

[0020] **FIG. 5B** is a side view of a shaft in accordance with one embodiment of the present invention;

[0021] **FIG. 6A** is a top plan view of a system in accordance with one embodiment of the present invention showing two artificial spinal disks placed side-by-side in substitution for a spinal disk;

[0022] **FIG. 6B** is a top plan view of another system in accordance with another embodiment of the present invention showing two alternative artificial disks placed side-by-side in substitution for a spinal disk;

[0023] **FIG. 6C** is a top plan view of an alternative embodiment of the present invention showing an artificial spinal disk positioned such that a first spacer is on a left side of a patient and a second spacer is on a right side of a patient.

[0024] **FIG. 7** is a representation of a method for replacing a degenerated spinal disk in accordance with one embodiment of the present invention.

[0025] **FIG. 8** is a plan view of an embodiment of the invention with the upper housing removed and, which is insertable laterally into an intervertebral disk space.

[0026] **FIG. 9** is a cross-section taken through line 9-9 of **FIG. 8**.

[0027] **FIG. 10** is coss-section taken through line 9-9 of **FIG. 8** with an upper housing depicted.

[0028] **FIG. 11** is an alternative embodiment of the invention with the upper housing removed, and which is insertable laterally into an intervertebral disk space.

[0029] **FIG. 12** is a cross-section taken through line 12-12 of **FIG. 11** with an upper housing depicted.

[0030] FIG. 13 is a cross-section similar to FIG. 12 with the upper and lower housings each having two keels.

[0031] FIG. 14 is yet another an alternative embodiment of the invention with the upper housing removed, and which is insertable laterally into an intervertebral disk space.

[0032] FIG. 15 is a cross-section taken thought line 15-15 of FIG 14 with an upper housing depicted.

DETAILED DESCRIPTION

[0033] Systems and methods in accordance with the present invention can comprise one or more artificial spinal disks for replacing a degenerated spinal disk. **FIGs. 1A-1C** illustrate a cross-section along a sagittal plane of an artificial spinal disk **100** positioned between adjacent vertebrae in accordance with one embodiment of the present invention. The artificial spinal disk **100** comprises an upper housing **102** and a lower housing **104** that combined to form a cavity **114** that partially enclose an anterior spacer **106** and a posterior spacer **108**. The spacers **106, 108** are mounted on a shaft **110** of the preferred embodiments. The spacers **106,108** are urged apart by a spring **112** mounted concentrically on the shaft **110**. As can be seen in the Figures, the spacers **106, 108** are bell shaped with an inwardly sloping cylinder side that acts as a ramp relative to the upper and lower housings **102, 104.** As can be seen in FIG. 5B, the shaft **110** can comprise a plurality of segments of different diameters. Shaft **110** in this embodiment is fixed to spacer **108** and shaft **110** retains spacer **106** between stops. Thus spacer **106** can move relative to shaft **110** and is urged away from spacer **108** by spring **110**.

[0034] In one embodiment, a cross-section of each of the upper housing **102** and the lower housing **104** along a sagittal plane can have inner cavities or recesses **120, 122** that varies from an anterior end to a posterior end of the housing **102,104** and that have ramps **124, 126** and **128, 130** respectively, such that when the upper and lower housing **102,104** are urged together, for example by a compressive or torsional force applied to the artificial spinal disk **100**, spacer **106,** slides toward spacer **108**. It is to be understood that in an alternative embodiment that both spacers **106, 108** can be movably mounted on shaft **110** and thus when a load is placed on artificial spinal disk **100**, both spacers **106, 108** can slide towards each other. Accordingly can be seen in **FIG. 1A-1C**, the cavities or recesses **120, 122** of the upper housing **102** and lower housing **104** can each have a minimum depth at the anterior and posterior ends of the housing **102, 104** and a maximum depth approximately at the center of the housing **102, 104**. From a position at the center of the housing **102, 104** and extending outwardly in both directions, the depth of the cavities or recesses **120, 122** decrease in a linear fashion such that ramps **124, 126,** and **128, 130** are formed at each of the posterior and anterior ends. In other embodiments, the ramps can vary in a non-linear fashion such that the ramps can have a concave shape or a concave shape or a combinations of shapes.

[0035] As can be seen in **FIG. 1A**, the artificial spinal disk **100** also includes keels **140** and **142** extending from the upper housing **102** and the lower housing **104** respectively. The keels **140** and **142** are directed in this embodiment along a posterior/anterior line. In other embodiments described and depicted herein, the keels can be oriented laterally such that the keels are about perpendicular to the sagittal plane of the body. In other words the lateral

keels would be used for method which involved a lateral implantation of the disk **100** relative to the spine.

[0036] In the embodiment of **FIG. 1A**, the keels **140, 142** each have teeth, **144, 146** respectively. For embodiments that are inserted from a posterior to an anterior direction, as depicted in **FIG. 1A**, the teeth point in a posterior direction with a ramp facing an anterior direction. This configuration allows the keels to be more easily inserted into keel channels cut in the vertebral bodies, and helps to lock the keels in place. In general it is advantageous to have the teeth point in a direction that is opposite to the direction of insertion of the keel into the bone and in this particular situation into the vertebral bodies of the spine.

[0037] In the embodiment shown the keels include ports **148** and **150**. Bone from, for example, the vertebral bodies can grow thorough the ports and aid in securing the keels and the artificial disk **100** with respect to the vertebral bodies. In addition the keels and the surfaces of the artificial spinal disk **100** can be roughened in order to promote bone ingrowth into the surfaces of the artificial spinal disk **100**. By way of example only, such surfaces can be coated with a bone growth substance such as for example bone morphogenic protein, BMP or hyaluronic acid, HA, or other substance which promotes growth of bone relative to and into the keel, keel ports, and other external surfaces of the disk **100**. In addition in another embodiment these surfaces can be coated with cobalt chrome in order to provide a surface for bone-in growth relative to the replacement disk **100**.

[0038] **FIGs. 2A-2C** illustrate an artificial spinal disk **100** wherein an anterior end of the upper and lower housings **102,104** are urged together. As a spacer **106** slides toward spacer **108,** a gap between the upper housing **102** and the lower housing **104** at the anterior

end of the disk **100** lessens. For example, where a patient having an artificial spinal disk **100** bends forward, a bending force is applied to the anterior end of the artificial spinal disk **100**, causing the anterior spacer **106** to slide toward a posterior end of the artificial spinal disk **100** by sliding along ramps **124, 128** of the upper and lower housings **102, 104** respectively. The spring **112** is compressed. As shown in **FIG. 2B**, one end of the shaft **110** passes through the anterior spacer **106** such that the spring **112** is compressed. It is noted that in this embodiment, that although the anterior end of the upper and lower housings of the artificial spinal disk **100** are urged together, that the posterior end of the upper and lower housings maintains a spaced apart distance which is the same as prior to when the force was placed on the disk **100**, as for example depicted in **FIGs. 1A-1E**. That is to say that the maximum height of the disk **100** along the length of the disk **100** does not change. The disk **100** can be compressed at one end, with the other end either being compresses or maintaining the original height. This feature can be advantageous with respect to the anatomy or the spine, as the spine, due to ligaments and other tissues, may allow, for example, an anterior disk space to be compressed together and may not allow an opposed posterior disk space to be expanded. In a natural disk space of the spine, with the anterior disk space compressed, the posterior disk space generally can maintain the same height, or is also compressed. The embodiment of **FIGs. 3A, 3B** illustrate this feature.

[0039] The anterior spacer **106** stops sliding when a component of the bending force urging the anterior spacer **106** to slide along the ramp is balanced by a component of force of the spring **112** on the shaft **110** urging the anterior spacer **106** apart from the posterior spacer **108**, or until the upper housing **102** contacts the lower housing **104** and the gap is eliminated.

When the bending force is removed from the anterior end of the artificial spinal disk **100**, the force of the spring **112** on the shaft **110** causes the anterior spacer **106** to slide toward the anterior end of the artificial spinal disk **110**, urging the upper housing **102** and the lower housing **104** apart as the anterior spacer **106** slides on the ramps. The original gap can be restored in this manner by removing the bending force applied to the anterior end of the artificial spinal disk **100**. Similarly, as the patient bends backward, a bending force can be applied to the posterior end of the artificial spinal disk **100**, causing the posterior spacer **108** and shaft **110** to slide toward the spacer **106** and the anterior end of the artificial spinal disk **100**.

[0040] The cross-section of the artificial spinal disk **100** shown in **FIGs. 1A-2C** depict the upper and lower housings being of the same shape. In other embodiments, however, a cross-section of the upper housing **102** can differ from a cross-section of the lower housing **104**. For example, the lower housing **104** can be a flat plate substantially conforming to a flat surface of one or more spacers. In still other embodiments, the posterior end of the artificial spinal disk **100** can have a different configuration from the anterior end of the artificial spinal disk **100**. For example, where increased stiffness is desired, the posterior end can include a substantially flat portion, or a portion having a steeper ramp for the spacer thereby resisting flexion from bending in the backward direction. One of ordinary skill in the art can appreciate the different devices that can allow various movements between adjacent vertebrae.

[0041] As shown in **FIGs. 3A** and **3B**, the artificial spinal disk **100** can further comprise a clasp **114** or other locking mechanism connecting the upper and lower housings

102,104 together at anterior and posterior ends. A receiving end **116** for receiving the clasp **114** is formed in the opposite housing **102,104** so as to receive the clasp **114**. The clasp **114** can be adapted to prevent the gap between the housings **102, 104** from expanding beyond a maximum width, for example at the posterior end, when forward bending causes flexion at the anterior end. As the spring **112** is compressed by the sliding of the anterior spacer **106,** the force applied by the spring **112** on both the anterior spacer **106** and the posterior spacer **108** increases. Where no restraint is applied to the posterior end, the posterior spacer **108** can slide further toward the posterior end, causing the gap at the posterior end to increase beyond the original height. The clasp **114** can prevent expansion of the gap beyond a maximum height when a force is applied by the compressed spring **112** to the posterior spacer **108** during forward bending. The clasp **114** can further prevent shifting of the upper housing **102** relative to the lower housing **104.** In other embodiments, other mechanisms can be used. For example, the upper housing **102** and lower housing **104** can be tethered together.

[0042] The artificial spinal disk **100** are generally anchored or fixed to the vertebrae. Fixation can be achieved, for example, as previously described by, with one or both of the upper and lower housings **102, 104** including a keel **140, 142** which extend therefrom, which keels can include teeth **144, 146** respectively. Appropriate channels can be cut in the upper and lower adjacent vertebrae to receive the keels **140, 142** in order to retain the artificial spinal disk **100** relating to the vertebrae. Fixation can also be accomplished (1) by anchoring using one or more teeth, pegs, or posts extending from the upper and/or lower housing **102, 104** and inserted into the vertebrae (2) by promotion of bone-in growth by means of a porous contact surface of each housing **102, 104**, or (3) by fixation with screws through ports in the

upper and/or lower housings **102, 104**. In one embodiment, the top surface of the upper housing **102** can include teeth which can penetrate into the top vertebra, fixing the artificial spinal disk **100** with respect to the top vertebra. Similarly, the bottom surface of the lower housing **104** can include teeth which can penetrate into the bottom vertebra, fixing the artificial spinal disk **100** with respect to the bottom vertebra.

[0043] FIG. **4** illustrates a top down view of an artificial spinal device **100** in accordance with one embodiment of the present invention. The upper housing **102** and the lower housing **104** can be substantially rectangular in shape with rounded corners to ease insertion into the disk space if desired. A cross-section of the cavity **114** formed between the housings **102, 104** along the transverse plane can be elliptical in shape such that the sidewalls of the cavity **120, 122** roughly conform to the shape of the spacers **106, 108**, limiting shifting of the upper housing **102** relative to the lower housing **104**. In other embodiments, the cross-section of the cavities **120, 122** can have a different shape. For example, the cross-section of the cavity can be rectangular. In such a configuration the spacers would be block shaped with upper and lower ramps. Such a configuration would not respond to twisting or torsional forces as well as the embodiment shown in FIG. **4**. One of ordinary skill in the art can appreciate the different configurations for the cavity.

[0044] As shown in FIGs. **4** and **5A**, the anterior and posterior spacers **106, 108** can be substantially ovoid-shaped or bell-shaped. Each spacer **106, 108** can be radially symmetrical about an axis along the length of the cavity and can be truncated at a proximal and a distal end, for example to decrease the space occupied by the spacer **106, 108** within the cavity. In other embodiments, the spacer **106, 108** can have a different shape, such as, for

example, a wedge shape. A bore can be formed in each spacer **106, 108** for connecting the spacer **106, 108** with the shaft **110**. The bore can receive an end of the shaft **110** so that as the spacers **106, 108** are urged together, the spacers more together and relative to the shaft **110**. In an alternative embodiment, the anterior spacer **106** can include a tiered cylindrical bore that extends through the anterior spacer **106.** This structure can provide stops to limit the motion of the spacer **106** and the shaft **110** relative to each other. In still other embodiments, each spacer **106, 108** can include a collar **155 (FIG. 1A)** that is received in a recess of the shaft **110** to limit the motion of the spacers **106, 108** and the shaft **110** relative to each other. One of ordinary skill in the art can appreciate the different means and methods for connecting a shaft with a spacer.

[0045] The spacers **106, 108** and housings **102, 104** can be of various shapes and sizes. Thus for example, using imaging prior to surgery, the anatomy of the individual patent can be determined and the artificial spinal disk **100** selected to suit the particular patient. Additionally, during surgery the physician can be provided with a kit having different sized artificial spinal disks **100** to fit the anatomy of the patient.

[0046] The upper housing **102** and lower housing **104** and the spacers **106, 108** and shaft **110** can be made of stainless steel, titanium, and/or other bio-compatible metal or metal composite. Each component can be cast, milled, or extruded, for example. Alternatively, the upper housing **102** and lower housing **104** and the spacers **106, 108** and the shaft **110** can be made of a polymer such as polyetheretherketone (PEEK), (as defined below) or other biologically acceptable material. A material can be selected based on desired characteristics. For example, a metal can be selected based on high relative fatigue strength. Many patients

with back pain are in their lower fortie's in age. In such cases, it may be desired that an artificial spinal disk have a fatigue life of at least forty years, extending beyond a patients octogenarian years.

[0047] As indicated above, each spacer **106, 108** can be made of a polymer, such as a thermoplastic, and can be formed by extrusion, injection, compression molding and/or machining techniques. Specifically, the spacer **106, 108** can be made of a polyketone such as PEEK.

[0048] One type of PEEK is PEEK 450G, which is an unfilled PEEK approved for medical implantation available from Victrex of Lancashire, Great Britain. Other sources of this material include Gharda located in Panoli, India. PEEK 450G has appropriate physical and mechanical properties and is suitable for carrying the physical load exerted by the upper housing **102** and lower housing **104** while providing a smooth, slidable surface. For example in this embodiment PEEK has the following approximate properties:

Density	1.3 g/cc
Rockwell M	99
Rockwell R	126
Tensile Strength	97
MPaModulus of Elasticity	3.5 GPa
Flexural Modulus	4.1 Gpa

[0049] The material selected may also be filled. For example, other grades of PEEK available and contemplated include 30% glass-filled or 30% carbon-filled PEEK, provided such materials are cleared for use in implantable devices by the FDA or other regulatory body. Glass-filled PEEK reduces the expansion rate and increases the flexural modulus of PEEK relative to unfilled PEEK. The resulting product is known to be ideal for improved

strength, stiffness, or stability. Carbon-filled PEEK is known to enhance the compressive strength and stiffness of PEEK and lower its expansion rate. Carbon-filled PEEK offers wear resistance and load carrying capability.

[0050] As will be appreciated, other suitable bio-compatible thermoplastic or thermoplastic polycondensate materials that resist fatigue, have good memory, are flexible and/or deflectable, have very low moisture absorption and have good wear and/or abrasion resistance, can be used without departing from the scope of the invention. Other materials that can be used include polyetherketoneketone (PEKK), polyetherketone (PEK), polyetherketoneetherketoneketone (PEKEKK), and polyetheretherketoneketone (PEEKK), and generally a polyaryletheretherketone. Further, other polyketones can be used, as well as other thermoplastics.

[0051] Reference to appropriate polymers that can be used in the spacer can be made to the following documents, all of which are incorporated herein by reference: PCT Publication WO 02/02158 A1, dated January 10, 2002 and entitled Bio-Compatible Polymeric Materials; PCT Publication WO 02/00275 A1, dated January 3, 2002 and entitled Bio-Compatible Polymeric Materials; and PCT Publication WO 02/00270 A1, dated January 3, 2002 and entitled Bio-Compatible Polymeric Materials. Other materials such as Bionate®, polycarbonate urethane, available from the Polymer Technology Group, Berkeley, California, may also be appropriate because of the good oxidative stability, biocompatibility, mechanical strength and abrasion resistance.

[0052] Other thermoplastic materials and other high molecular weight polymers can be used. One of ordinary skill in the art can appreciate the many different materials with which a spacer **106, 108** having desired characteristics can be made.

[0053] **FIG. 6A** illustrates a top down view of a system comprising two artificial spinal disks **100** in accordance with one embodiment of the present invention. A device or system is typically designed to occupy approximately an entire cross-sectional area of the vertebra so that a spinal load can be distributed over a maximum surface area. A single artificial spinal disk sized to occupy the entire cross-sectional area may complicate surgical insertion that requires implantation of the artificial spinal disk through an open anterior approach. To minimize the incision size, a plurality of artificial spinal disks can form a system in accordance with one embodiment of the present invention for replacing a degenerative spinal disk. By implanting each artificial spinal disk **100** separately, a smaller incision is required, thereby allowing for a posterior approach. As shown in **FIG. 6A**, the system can comprise two artificial spinal disks **100**. However, in other systems three or more artificial spinal disks can be used, or even a single artificial spinal disk. The size of each artificial spinal disk and the number of artificial spinal disks connected can depend on the location of the adjacent vertebrae (for example the defective spinal disk may be a lumbar disk or thoracic disk), the preferences of a surgeon or the preferences of a patient, for example.

[0054] First and second artificial spinal disks **100** can be connected together at one or more locations, preferably along opposing surfaces, preventing shifting of one artificial spinal disk **100** relative to the other. The artificial spinal disks **100** can be connected using one or more snaps, pins, screws, hinges or other fastening device **111**. One of ordinary skill in the art

can appreciate the methods for connecting multiple artificial spinal disks **100** after each disk **100** is separately implanted between adjacent vertebrae.

[0055] By way of example, an incision can be made posteriorly from the left or right of the spinous processes. The disk space can be cleaned and tissue removed as required. Then disk **100** can be inserted through the incision. Thereafter, the second disk can be inserted into the disk space through the disk space through the incision. Once the second disk **100** is positioned the two disks can be secured together by for example inserting a pin or screw between aligned eyelets extending form the disks **100** as seen in **FIG. 6A**.

[0056] As can be seen in **FIGs. 6B, 6C** in other embodiments, an artificial spinal disk **600** can comprise a first spacer **606** and a second spacer **608**, each spacer being positioned at an opposite end of a shaft **610**, which shaft is substantially parallel to a sagittal plane. The shaft **610** allows for urging the spacers **606, 608** toward each other. The artificial spinal disk **600** permits flexion from side to side. The artificial spinal disk **600** can comprise an upper housing **102** and a lower housing **104** that together form a "kidney bean" shaped cavity **612.** The kidney shaped cavity **612** can accommodate side to side bending with simultaneous twisting or tortional motion of the spine. The separate disks **600** can be implanted and joined together or described above with respect to **FIG. 6A**.

[0057] **FIG. 7** is a block diagram showing steps for performing a method for inserting a disk **100** into a patient in order to replace a degenerated spinal disk or otherwise defective spinal disk in accordance with the present invention and using a posterior, anterior or lateral approach. As shown in first block **700**, an artificial spinal disk is selected according to the size of the spinal disk to be replaced and the degree and character of the freedom of

movement desired. In one embodiment, a first and second artificial spinal disk **100** as shown in **FIGs. 1A-1E** can be selected. In an alternative embodiment, a single artificial spinal disk **600** as shown in **FIG. 14** can be selected. An incision is made in the patient proximate to the defective spinal disk (step **702**), and the spinal disk and surrounding tissues are exposed. The adjacent vertebrae are braced (if required), so that the defective spinal disk can be removed (if required), allowing for replacement by the artificial spinal disks **100** (step **704**). An artificial spinal disk **100** can be inserted through the incision and positioned between the adjacent vertebrae (step **706**). For this procedure, the nerve and other structures of the spinal column can be retracted out of its way. Minor adjustments in positioning can then be made (step **710**) followed by removing the braces (if used) (step **712**). The incision is closed (step **714**).

[0058] Also it is to be understood that as described below, an artificial spinal disk can be inserted laterally into a disk space between two adjacent vertebral bodies. In this method the spine is approached laterally and disk tissue is removed as is appropriate. Then the disk **100** is inserted along a lateral direction.

[0059] Other methods of insertion include having the disk **100** disassembled prior to insertion. For this method, an upper or a lower housing **102, 104** can first be inserted and either loosely positioned or fixed to a vertebra, followed by a first spacer **106**, a shaft **110**, and a second spacer **108**. The housing **102, 104** can then be joined or snapped together using the mechanism shown in **FIGs. 3A, 3B**. The procedure can be repeated for multiple artificial spinal disks.

[0060] **FIGs. 8-15** depict artificial spinal disks that are preferably inserted using a

lateral approach to the spine along a direction that is substantially perpendicular to a sagittal plane of the spine.

[0061] In these embodiments, elements that are similar to the elements of prior embodiments are similarly numbered. In FIGs. **8-10** an artificial spinal disk **800** includes upper and lower housings **802** and **804** which together define a cavity **814** that partially enclose lateral spacers **806** and **808**. The spacers **806** and **808** are mounded on a shaft **810** with a spring **812** moved over the shaft so as to urge spacers **806** and **808** apart. The spacers in this embodiment are larger, broader and flatter than the spacers in prior embodiments in order to carry and spread out the load from the spinal column.

[0062] As can be seen in FIGs. **9** and **10**, the spacers **802, 804** are somewhat elliptical or football shaped in cross-section. In the plan view of FIG. **8**, the spacers **802, 804** are depicted as somewhat wing-tip shaped. The spacers **806, 808** are received in cavities or recesses **820, 822** provided in the upper and lower housings **802, 804** respectively. These recesses are similar to recesses **120, 122** although somewhat flatter. These recesses **820, 822** have the same cross-section as do recesses **120, 122** as seen in FIG. **1A** in that each includes a ramp at either end of the recess with a central portion having a greater depth than the ramped portions of the recesses. The spacers **806, 808** are similarly mounted on the shaft **810** as are spacers **106, 108** mounted on shaft **110**.

[0063] The upper and lower housings **802, 804** further include keels **840** and **842** which can be similar in design as keels **140** and **142**. In this embodiment, however, the keels **840, 842** are provided along a lateral orientation with respect to the spine. In order words, the keels are provided on disk **800** so that after disk **800** is implanted, the keels are substantially

perpendicular to the sagittal plane of the spine. The keels **802, 804** are preferably provided parallel to and over the shaft **810** in order to balance the load of the spine on the disk **800**. Such an arrangement provides stability to the disk **800** with respect to bending of the spine from flexion to extension in the sagittal plane.

[0064] The present embodiment is preferably implanted laterally or substantially perpendicular to the sagittal plane of the spine. Accordingly the method of implantation is similar to that described in FIG. **7** except that the approach to the spine is laterally instead of a posterior approach.

[0065] FIGs. **11-13** depict another embodiment of the invention that is preferably implanted laterally or substantially perpendicularly to the sagittal plane of the spine. In this embodiment elements similar to elements of prior embodiments are similarly numbered. In this embodiment, however, each implant includes two pairs of spacers **1106, 1108** which are mounted on substantially parallel shafts **1110** and urged apart by springs **1112**. It is to be understood that the shafts **1110** can be other than parallel and be within the spirit and scope of the invention. For example the shafts can be placed in somewhat of a "v" shape with the base of the "v" pointed to the posterior of the spine and the open end of the "v" pointed to the anterior of the spine. The spacers **1106, 1108** are preferably similar in shape to the bell shaped spacers in FIG. **1**. The recess **1122** is similar in shape, having the ramps at the ends as the recesses **122** in the first disk embodiment **100**. The disk **1100** operates in the same manner as the disk **100** or to be more specific, similar to two disks **100**, placed side-by-side. As the disk **1100** can be implanted laterally, there is no need to have the disk divided into two portions as is the case with the disk of FIG. **6A** which is implanted with a posterior approach.

Further it is to be understood that the disk **1100** can also be inserted using an anterior approach.

[0066] As can be seen in **FIGs. 12, 13** the lateral implantation approach is preferred due to the laterally oriented keels **1140, 1142**. These keels are similarly oriented as are the keels depicted in **FIGs. 9, 10**. In **FIG. 13** both the upper and the lower housings include a pair of keels **1140, 1142** respectively, with the keels preferably located over the spacers **1106, 1108**. The keels can have the same ports and bone ingrowth enhancements as the other keels described above.

[0067] With respect to **FIGs. 14, 15** the artificial spinal disk **1400** includes elements that are similar to those described above and these elements are similarly numbered. This embodiment is also preferably implanted using a lateral approach although an anterior approach can also be used. The embodiment of these figures has spacers **1406, 1408** which are similar in design to the spacers of the embodiment of **FIG. 8-11** with the exception that the shaft **1410** and spring **1412** are oriented along an anterior/posterior direction and not laterally as shown in **FIG. 8**. The spacers **1406, 1408** are received in recess **1422.** This embodiment also includes laterally disposed keels **1440, 1442** with all of the above advantages attendant with laterally disposed keels.

[0068] It is to be noted that in a number of these Figures the implants are illustrated against a kidney-shaped background that is representative of the plan view shape of the disk space between vertebral bodies.

[0069] The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations will be apparent to one of ordinary skill in the relevant arts. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. Other features, aspects, and objects of the invention can be obtained from a review of the specification, the figures, and the claims. It is intended that the scope of the invention be defined by the claims and their equivalence.